THE GEOLOGY OF MEDIUM-SIZED BASINS ON MERCURY: IMPLICATIONS FOR SURFACE PROCESSES AND EVOLUTION.

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Images returned by NASA's MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft have enabled Mercury's impact basins to be investigated in unprecedented detail. We are studying the morphology and stratigraphy of medium-sized basins (diameter 120-200 km) to determine their common characteristics, particularly how they are modified by volcanism, tectonics, and subsequent impacts. The majority of peak-ring basins on Mercury have diameters greater than ~100 km [1], so most of the basins in our study are expected to have, or to have had, peak rings when they formed. Thus the presence or absence and characteristics of a peak ring in the larger basins is a key observation in understanding peak-ring populations and the processes by which basins on Mercury are modified. We compare our results to studies of larger basins on Mercury to determine whether there are characteristic basin diameters for which specific processes dominate [2-5]. This work also constrains the relative roles of volcanism and tectonics on Mercury through time.

For this study, we analyze data collected during MESSENGER's orbital phase and flybys of Mercury. We use monochrome base map images with an average resolution of ~250 m/pixel; color images acquired during global mapping or aimed at specific targets, with typical resolutions of ~1000 and ~300 m/pixel respectively; and targeted images of selected areas acquired at resolutions as high as 15 m/pixel. Our initial study area contains nine similar-sized basins within a region covering ~50° in longitude and 40° of latitude (Fig. 1). This area contains an unusually large number of well-preserved medium-sized basins, which have undergone a variety of modificational processes. The basins appear to range in relative age and to have been modified by the emplacement of stratigraphically younger smooth plains and/or by tectonic deformation. We have also studied a tenth basin, Derain (diameter 167 km), which lies to the west of the main study region. Six of the basins studied are shown in Figure 2. Eventually we will incorporate into our study all basins on Mercury within the chosen size range

Volcanic modification: All of the basins contain smooth plains material, formed either as impact melt or as volcanic fill. In all but one of the basins, volcanism is evidenced by small craters within the basin interiors that have been almost completely filled by smooth plains (arrows, Figs. 2d, e). Another indicator of volcanism subsequent to basin formation is found in three of the basins, which contain plains material within their peak rings having color characteristics distinct from the annular plains within those basins (Fig. 2b). This pattern is similar to that for plains material within the peak ring of the Rachmaninoff basin, which has distinctive color characteristics and appears to be much younger than the basin itself. The Rachmininoff interior plains have been interpreted to be among the youngest volcanic material on Mercury [5].

Impact modification: Some of the basins in our study area have been overprinted by later impacts or ejecta from nearby basins or craters. In some cases, the basin is largely obscured by these later events (e.g., Fig. 2c), whereas elsewhere the overlying craters have only partially obscured the original basin rim or peak ring (e.g., Fig. 2e). For most basins, interior material appears relatively sparsely cratered.

Tectonic modification: The interiors of some of the basins exhibit distinct curvilinear scarps (arrows, Fig. 2a). Some are confined to the basins (i.e., they do not continue beyond the basin rims), whereas others can be traced outside the basins into the surrounding terrain as lower-relief lobate scarps. We interpret these scarps as contractional tectonic features, consistent with the view that basins act as foci for localizing deformation.

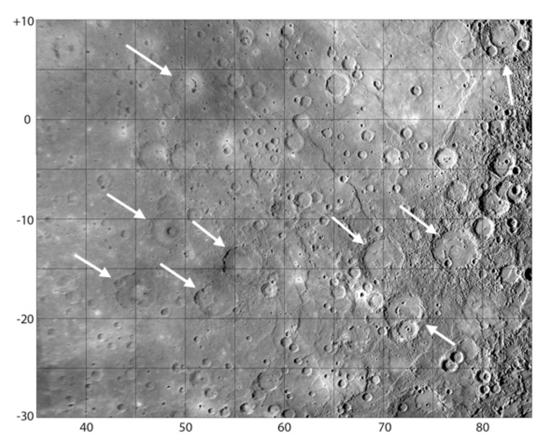

Figure 1. Initial study region showing nine medium-sized basins on Mercury (arrows) that have undergone a variety of modification processes.

Extensional troughs have been observed in several of Mercury's largest basins [e.g., 2-5], and we find a small number of disorganized troughs in the Derain basin (Fig. 2f). However, most of the basins in this study do not show any evidence of extensional deformation, suggesting that these features are more likely to form in larger basins. If troughs in larger basins result from some combination of flexural stresses due to subsidence and stresses from cooling of basin fill [6,7], then it is possible that the majority of the basins in our study did not have the necessary interior fill thickness and/or geometry for extensional faulting to occur.

Other modification: Some of the basins in our study have distinct morphological features along the trace of their original peak rings, which may no longer be visible. Such features include rimless depressions (Fig. 2a), such as have been observed within craters and basins elsewhere on Mercury [8]. Some such depressions have been interpreted to be sites of past explosive volcanism [2, 8-11]. The Derain basin is unusual in that part of its peak-ring material appears to have been removed to just below the surface by a process interpreted to be related to hollow formation (arrow, Fig. 2f) [12]. This removal may indicate that the peak ring contained volatile-rich material that was subsequently devolatilized by sputtering or thermal interactions with impinging lava flows [12-14].

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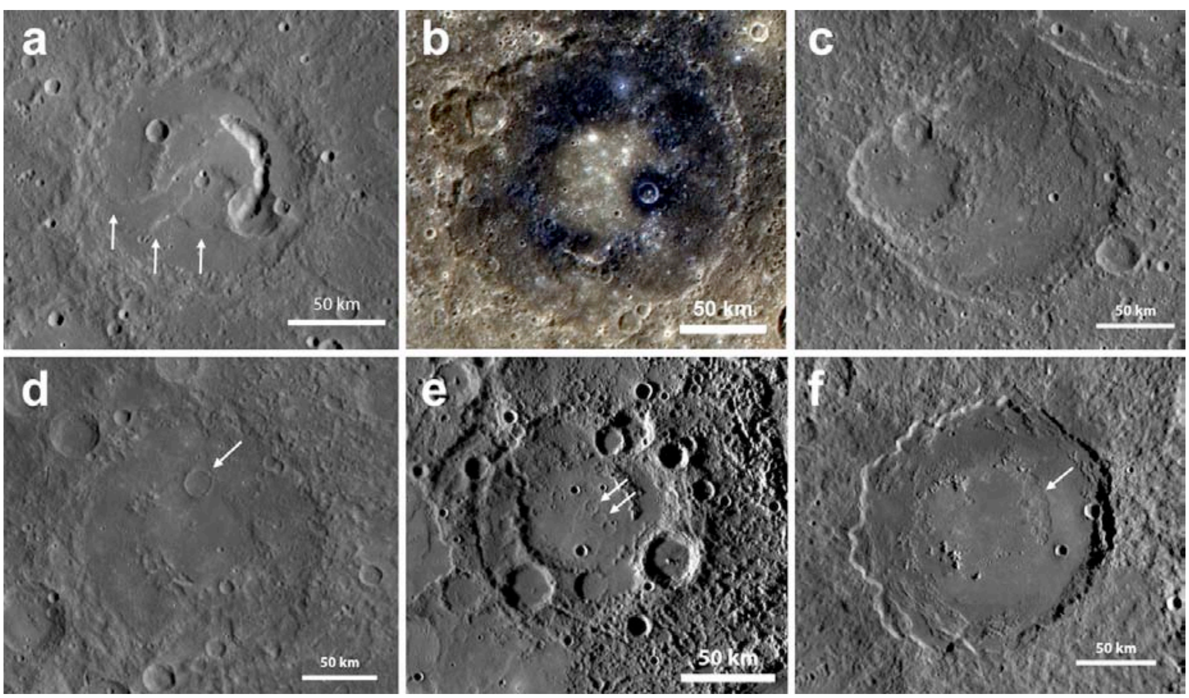

Figure 2. Six of the medium-sized basins on Mercury analyzed in this study. (a) Picasso basin, which shows several contractional tectonic features (arrows) as well as distinct arcuate depressions along the trace of its original peak ring. (b) Color image of unnamed basin (1000, 750, and 430 nm filters). Material within the peak ring has different color characteristics from those in the basin's annulus and may represent volcanic material emplaced within the basin some time after it formed. (c) Unnamed basin that has been heavily modified by subsequent impacts and ejecta from an adjacent basin to the northeast. (d) Unnamed basin filled with smooth volcanic plains material. Arrow points to rim of crater that has been filled with volcanic material. (e) Unnamed basin that has undergone impact and volcanic modification (arrows point to rims of flooded craters) but for which the rim and central peak are still visible. (f) Derain basin, where smooth plains have almost obscured the central peak ring. The eastern portion of the peak ring has been replaced so that all that remains is a shallow, rimless, pitted depression, possibly the result of volatile removal.